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NEWS FROM THE STARS[1]

By Robert G. Aitken

Like the Athenians in the days of St. Paul, we all delight to tell or hear of some new thing. "What's the news?" is a standard form of greeting and few of us can pass a bulletin board or a newsboy shouting "extra" without stopping to get the news. And marvelous indeed is the organization that makes it possible for us to learn each day the more important items of news from every part of the civilized world. Whether it is that Steffanson has reached Fort Yukon after his long stay in the Arctic regions, that Guatemala has been visited by a disastrous earthquake, or that General Allenby has entered Jerusalem on foot, the agents of the Associated Press have noted the fact almost before the event and we read of it next morning in our daily paper.

At the present time, of course, the news we are all most eager to hear is the news from "over there," and in this the astronomer is as keen as the most "practical" man of business. I am well aware that the latter sometimes regards the astronomer with a certain air of good-humored tolerance, as a man who walks with his head in the clouds and his eyes fixed upon the stars, oblivious of the ordinary, or even the extraordinary, affairs of our common daily lives. And it would indeed seem that if any were to be unaffected by the present war it might well be a little company of men dwelling upon a more or less isolated mountain top, engaged in the purely scientific study of the stars.

But let me bear witness that we are united with you in one brotherhood in our love of country and of righteousness, and that we are striving even as you to do our part toward making justice and right prevail upon the Earth. Every man, woman, and child, even to the month-old baby, in our little community on Mount Hamilton is a member of the American Red Cross; every girl and woman is giving every possible minute to knitting and

[1] Third Adolfo Stahl Lecture, Jan. 11, 1918.

sewing for the Red Cross; every employee of the Lick Observatory holds at least one Liberty Bond; every household is conscientiously conserving food and fuel; our little community has "gone over the top" in every "drive" for funds, beginning with the appeals for relief long before the first Red Cross drive last spring. And that is the least of it. Practically every family has near relatives at the front, and four of our boys, sons of the three astronomers who have boys old enough to serve, are volunteers in the active military service of their country. Two are in France at this moment, Lieutenants in the Engineer Corps and in the Aviation Service; one is on board a man-of-war, and the fourth is in the Marine Corps. Yes! I think I may say that the astronomers on Mount Hamilton are interested in the news—*all the news*—bearing in any way upon the war.

It is our personal duty, meanwhile, quietly to continue getting the news from the stars and making it known to those who may be interested. In this work we cannot rival our friends of the Associated Press in promptness. However alert we may be, however quick to seize and decipher the messages flashed to us with the speed of light from "the marches and strongholds of space," our news lags far behind the event. You were doubtless reminded of that fact if you read an article that appeared in one of the San Francisco papers one morning in December. The headlines ran

THIS NEWS IS LATE, BUT HERE IT IS AT LAST

EXTRA! EXTRA! ALL ABOUT BIG DISASTERS OF 20,000,000 YEARS AGO

THREE SUNS BLOWN UP

Information Reaches Earth Finally as Tiny Specks on Photographic Plate

The article was based upon a Lick Observatory Bulletin announcing the discovery by Dr. Curtis of three Novae, new stars, in spiral nebulae, and barring the statement of the "blowing up" of three suns and of a few other details was accurate enough and certainly very interesting reading. A cipher or two might perhaps be dropped from the number of years given in the headlines quoted, but, at best, the news was a very long time indeed in reaching us, measured by the standards of our human experience. I

shall tell you more about this item of news a little later on but just now I want to ask you to fix your attention on the stars which shine upon us in the early hours of these winter evenings when we face the south and look up into the sky.

There are few regions of the starry heavens more attractive to the unaided eye than the one now spread before you. High in the sky, near the zenith, is the little group of the *Pleiades*; south and to the east from them stand the *Hyades*, with ruddy *Aldebaran* for their leader; still farther southeast is *Orion*; and towards the southeastern horizon, *Sirius*, the brightest star in the sky. East and a little north from the red star *Betelgeux*, *Alpha Orionis*, shines *Procyon*, and north and slightly east of *Procyon* the twin stars, *Castor* and *Pollux*. The great planet *Jupiter*, between the *Pleiades* and *Aldebaran*, and *Saturn*, low in the eastern sky, are added attractions during the present winter.

Beautiful as it is to the unaided eye, every increase in optical power as we apply the telescope to the various parts of this section of the sky brings out new wonders. Not only is the apparent number of stars increased beyond our power to count but many of them are found to be double or multiple; others, to be surrounded by those cloud-like masses of light which we call nebulae. *Theta Orionis*, the middle star in the sword of *Orion*, for example, which, indeed, is hazy to the eye alone, is now seen to be a nebulous mass entwined about a little group of stars. This object, commonly known as the *Great Nebula in Orion*, is in fact one of the most remarkable in the whole heavens and it is one about which we have recently been finding out some new facts which I am sure will be of interest to you.

To realize their significance it will be necessary to glance briefly at the history of this nebula as revealed by the telescope. As long ago as 1656 Huyghens, the astronomer whose careful observations paved the way for Kepler's discovery of the laws of planetary motion, saw three of the stars in the little group of the now familiar *Trapezium*; the fourth was certainly known in Herschel's time, and, later, fainter companion stars were added to two of the four. One or two excessively faint stars within the *Trapezium* were discovered by Alvan Clark and by Barnard with our 36-inch refractor, and Frost and Adams, at the Yerkes Observatory, found the brightest star of the *Trapezium* to be a spectroscopic binary system. Merely as a star group, then, *Theta Orionis* is a wonderful

object; a group of suns forming a single physical system of a size so vast that our solar system, in comparison, shrinks to insignificance. But far more wonderful is the cloud-like mass of greenish-white light enveloping these stars. Just visible to the naked eye as a hazy patch, the brighter part is readily seen with a pair of opera glasses; but to get an adequate idea of its beauty, its extent, and the bewildering complexity of its details it is necessary to view it with a powerful telescope, or to study a photograph taken with a large modern reflector. It is hopeless to attempt description, just as many able astronomers in earlier days found it hopeless to try to portray all of its features by even the most careful drawings.

I have called it a nebula, but that term is applied to at least three different classes of objects, the spirals, the planetaries, and the irregular gaseous nebulae. Our object belongs to the third category, for the spectroscope long ago showed that it consists of gases shining by inherent light, but whether this light is due to intense heat or to some other cause it has been impossible to say. The great difficulty about believing it to be due to heat is the almost incredible extent and tenuity of the nebula. On the photographs taken with the Crossley reflector both the north and south, and the east and west diameters exceed 40 minutes of arc. To translate this value into linear measure, miles or kilometers, it is necessary to know how far away the object is. This we do not know, but it is possible to set a *minimum value* for the distance. The parallax is certainly less than 0.01 second of arc; that is, a line 93,000,000 miles long (the distance from the Earth to the Sun), drawn upon the surface of the nebula would to our eyes subtend an angle of 0.01 second of arc. The diameters of the nebula are therefore certainly more than 240,000 (40x60x100) times 93,000,000 (22,320,000,000,000) miles and may be more than ten times as great. Some one has computed that if the material were only 1/1,000,000 as dense as ordinary atmospheric air at sea-level, the mass of the nebula would be so great as to compel all of the stars in that region of space to travel toward it. As a matter of fact no such motion is observed and the tenuity must be even less than the almost incredible limit named. That such a mass of matter can be hot enough to be incandescent is hard to believe, but recent investigations indicate that this is the case.

Every effort has been made to determine whether there are any changes in the position of the nebula as a whole or in any of

its parts, but without positive results. This does not, of course, mean that the nebula is absolutely stationary in space but only that whatever motion there may be across the line of sight is too small to become apparent to us in the time during which accurate measures have been made. In this interval there may have been a motion of translation amounting to some hundreds of millions of miles, but the resulting angular displacement would be so small that we should not be able to detect it. The spectroscope, however, permits us to make accurate measures of the motion of a celestial body *in the line of sight* no matter how far away the body may be. Its testimony is to the effect that the Sun and the nebula as a whole are moving away from each other with a velocity of about 18 kilometers a second; but by far the greater part of this relative velocity is due to the Sun's own motion thru space and only a small fraction to the actual motion of the nebula. In fact, this nebula, like other diffuse gaseous nebulae, seems to be almost stationary when compared to the motion of the average star.

The materials of the nebula, however, are far from being in a quiescent state. Three or four years ago MM. Buison, Fabry and Bourget, at Marseilles, applied an interferometer attached to a 24-inch reflecting telescope to its study. In effect this apparatus resembled a spectrograph in that it permitted the observers to make accurate measures of the radial velocity of the portion of the nebula examined, and it had the advantage over the ordinary slit-spectrograph of permitting such measures to be made over every part of a field some 4′ in diameter on a single photograph. These investigators found that different parts of the nebula were moving with different velocities. The interferometer has the further advantage of giving, under certain conditions, a theoretical value of the atomic weight and of the temperature of the gas whose radiation is measured and, in the present instance, the authors were led to conclude that the atomic weights of the unknown gases in the nebula were intermediate between that of hydrogen and that of helium, and that the temperature might be as high as 15,000° Centigrade. Conclusions of such fundamental importance to our theories of stellar evolution will, of course, be most carefully verified before they are finally adopted, but the ability of the investigators and the scrupulous care they took to check their work at every stage lends great weight to their results.

Recent spectrographic measures at the Lick Observatory and

elsewhere have fully confirmed these results so far as the internal motions are concerned. A detailed study of the *Orion Nebula* has formed part of the program of work with the Mills Spectrograph during the past few years and accurate measures of the radial velocities of the gases in many different parts have been made. It is found that in some parts they are receding relatively, in other parts approaching, the relative velocities occasionally exceeding 10 kilometers per second. The whole mass, therefore, must be conceived of as being in seething and well-nigh chaotic turmoil.

Now this is one of the latest items of news we have received from the *Great Nebula in Orion* and it illustrates very well the impossibility of having our astronomical news even approximately contemporaneous with the event. The motions which were recorded by the spectrograph were those indicated by the light waves which entered the slit, but those light waves left the nebula certainly more than 300 years ago!

Let me give you another illustration. Somewhat east of the region we are considering there is a star known as *Epsilon* of the constellation *Hydra*. Long ago Struve found that this was a double star, one component being decidedly fainter than the other. In 1888, Schiaparelli noted that the brighter component was itself a very close double, the two components again being quite unequal in brightness. Now I followed the motions in this close pair by measuring the relative positions of the two components with the 36-inch telescope for 15 years, during which time the fainter star seemed to make a complete revolution about the brighter one, and from these measures I computed the elements of the orbit. At the same time measures made with the spectrograph showed that the motion of the brighter star in the line of sight was variable and an independent determination of some of the elements of the orbit was thus made possible. Moreover, from the two determinations it was possible to calculate with considerable accuracy how far away the system was. It proved to be about 135 light years distant. Therefore the revolution of the two stars which I witnessed was not the one actually taking place during those 15 years, but the one which took place 135 years earlier, or during the days of our own Revolutionary War! Since then the small star has travelled about the brighter one (more precisely, the two stars have travelled in their orbits about their common center of gravity) fully nine times and during the next 135 years the light waves telling us of those motions will reach the Earth. It is literally true that the

student of stellar motions is a student of ancient history, and is an eye-witness of events which happened centuries ago.

Let us return to the constellation of *Orion*. The photograph now upon the screen[1] shows that the so-called *Great Nebula* is really only a very small part of the nebulosity which winds about the entire constellation. This vast faint nebulosity is best photographed with quite small telescopes, which at first thought may seem very strange. The explanation is found chiefly in the fact that our large telescopes cover only a small sky area at any one time, whereas a small telescope of reasonably short focal length includes a large area. A small portion of the *Orion* nebulosity was seen by Sir William Herschel with his great reflector more than a century ago, but in more recent years its existence was doubted because certain photographic telescopes, of great power for many classes of work, failed to show it. In 1889, however, Professor W. H. Pickering, in the course of his tests of atmospheric conditions on Mount Wilson, now the site of the Solar Observatory, photographed this remarkable object with a portrait lens of 2.6 inches aperture and 8.6 inches equivalent focus. In 1894, Professor Barnard was experimenting at the Lick Observatory with a little lens taken from a cheap (oil) projecting lantern. The lens was but 1.6 inches in diameter and had an equivalent focus of 6.3 inches. Unconscious of Pickering's work, he photographed the constellation of *Orion* and fully verified the existence of this great enveloping nebula. In gathering news from the stars, then, we use visual and photographic telescopes ranging in aperture from a single inch to the 100 inches of the great reflector on Mount Wilson of which Professor Ritchey will tell you in his lecture in April; and we attach to these our spectrographs, photometers and other apparatus for special investigations.

There are other constellations which contain similar diffused and faint nebulae. One the most interesting of these surrounds the little group of the *Pleiades*, in the constellation *Taurus*, a group of stars that is, perhaps, the most familiar of any in the sky. The average eye sees six stars in this little group; keener eyes, especially in the clear air of mountain regions, distinguish seven or eight or even more. A small telescope greatly increases the number, but, unlike some globular clusters, the number cannot be increased indefinitely by photographing the region with telescopes of ever greater power. The entire group, as I have said, is involved

[1] The lecture was illustrated by many lantern slides.

in nebulosity similar to that which encircles *Orion*. This was first noted by Professor Barnard but has since been photographed by a number of different astronomers. Attention in recent years has been concentrated upon other features of the *Pleiades* group, particularly upon the brighter stars and upon certain remarkable nebulae associated with them.

The most recent study of the stars in the cluster is that just completed by Dr. Trümpler, at the Allegheny Observatory. He finds that the cluster includes from 80 to 90 stars as bright as 9.0 magnitude (bright enough, that is, to be just visible in a telescope of one-inch aperture), with probably 55 more stars between magnitudes 9.0 and 9.5. Doubtless, stars still fainter belong to the cluster but a large percentage of the faint stars of the region certainly form part of the stellar background upon which we see the cluster projected. We can distinguish between the two classes of stars by the fact that the cluster stars are moving together thru space. And it also appears that the stars thus moving together resemble each other in the character of their spectra. These two qualities, community of motion and resemblance of spectrum, lead us to conclude that the stars in the cluster had a common nebulous origin, and it is not at all improbable that in the nebulosity surrounding the group we see the remnant of the material out of which the stars were formed.

In addition to the apparent association of stars and nebulosity, there are several arguments in favor of this view. For example, long exposure photographs, like those taken with the Crossley reflector, show that some of the brightest stars in the group are immersed in nebulosity and the spectrograph testifies that they have extensive gaseous atmospheres with relatively small cores of denser matter. In other words, they are probably still in the earliest stages of their development as stars. Again Slipher has shown that the light of the nebula associated with *Merope*, one of the bright stars of the *Pleiades* has precisely the same quality as the light of the star. He finds the same to be true of the star *Maia* and its nebula, and, more recently, he and Pease at the Solar Observatory have found two other instances of star and nebula which possess light of identical quality. Slipher has argued that this indicates that the nebula is shining not by its inherent light but by light reflected from the star or stars, and Hertzsprung's photometric measures in the case of the *Merope* nebula bring confirmatory evidence. Whether we accept or reject the ex-

planation, the observations show the close connection of the two classes of objects. It is a most interesting fact that *Merope* and *Maia* and the other two stars which have so far been found to be attended by nebulae radiating light of the same quality are "helium stars," that is, stars in whose spectrum the lines of helium are strongly marked. For the stars in general have been classified according to the character of the spectrum they exhibit and it has been found that the blue-white helium stars stand at one end of a continuous series running thru white, yellow, orange and red to deep red stars. On what may be called the classical theory of stellar evolution this order represents the successive stages of stellar development from infancy to old age. In recent years the classical theory has been strongly challenged and a substitute theory offered according to which the youngest stars as well as the oldest are red and the blue-white stars occupy a middle position. This is not the place to present the forceful arguments brought to the support of each of these hypotheses, or to discuss their relative merits. I have mentioned them merely to point out that one of the greatest difficulties in the way of the acceptance of the two-branched evolutionary theory is the close association of the helium stars with diffuse nebulosity such as exists in the constellation of *Orion* and in the *Pleiades*. There is no correlation whatever between such nebulae and red stars.

This is perhaps as good a place as any to insist upon the necessity of discriminating between the facts of observation and the theories which may be based upon those facts. Tho elementary, the distinction is frequently lost sight of and astronomy, or rather the reputation of the astronomer, suffers. It is a fact that the companion star in the system of *Epsilon Hydrae* changes its position continuously with respect to the brighter star in such a manner that after 15 years it returns to its apparent starting point. The theory is that this change is due to the motion of the two bodies in elliptic orbits about a common center of gravity under the law of gravitation. In this case the evidence from numerous double stars is so overwhelmingly strong that the theory has as much weight as the observed facts. In other instances, as for example, the identity in the quality of the light of star and nebula or the arrangement of stellar spectra, the facts are beyond question but they may perhaps be subject to more than one interpretation. We are quite willing to abandon any theory, however cherished, whenever the facts fail to support it.

Let us again return to the constellation of *Orion* in order to consider a photograph taken by Dr. Curtis with the Crossley reflector only a week ago. The photograph shows the region just south of *Zeta Orionis*, the eastern star of the three in the "Belt."[1] Passing over other features, I want to call your attention to the sharply marked dark blotch, like an ink-blot, just above the center of the picture. At first sight it might be taken for a defect of some kind in the film. That it is not a defect was demonstrated by the fact that it reappeared in identically the same position on a different plate of the region taken on the following night. The reality of the marking being thus established, the question arises whether it represents a non-luminous substance which obstructs the passage of light from the luminous area into which it projects or whether it is a vacant region in space, a "tunnel" bored through the fabric of the constellation. This particular marking has not, so far as I am aware, been photographed before; the picture before you gives one of the latest items of news received from the stars; but "black holes" have long been known in certain regions of the Milky Way and are beautifully pictured in many of Barnard's photographs as well as in those taken by other observers.[2]

Twenty years ago it was thought not impossible that these markings might really represent vacant regions of space, but further investigation of them with modern photographic telescopes, an investigation in which Professor Barnard has been especially prominent, has led to the abandonment of this hypothesis by most astronomers. The edges of the markings are usually far too sharp, the forms are frequently too strikingly similar to those of bright nebulae, and too many of the dark patches are found in regions where it is impossible, on any reasonable theory of stellar distribution, to account for the sudden absence of faint stars.

It is of course conceivable that a compact cluster of stars rushing thru space might clear a path for itself and leave a vacant lane; but in the cases known to us there is no evidence of the existence of such a cluster in any position where it might be assumed to be after making such a lane. Hence if any one of these "holes" had such an origin the cluster must have passed many million years ago. But in this event we would not have the sharply

[1] See the photograph facing page 66 of the present volume of these *Publications*. In his note accompanying the photograph (written after my lecture was delivered) Curtis gives a more detailed description of this region.

[2] Several examples were shown on the screen.

cut outlines, for the stars are all in motion and, as Dr. Campbell has pointed out, these motions would in such a time interval have carried many stars into the vacant region, obliterating the clear-cut edges and possibly the "hole" itself.

On the other hand, Bessel long ago remarked that luminosity is not a necessary property of cosmical bodies. "The visibility of countless stars is no argument against the invisibility of countless others." If this may be true of stars there is no apparent reason why it may not be true also of nebulae. As a matter of fact we have quite definite evidence of the existence of dark objects of both classes and some of the strongest of this evidence is furnished by the Novae, or new stars, such as are the subject of the newspaper article to which I referred a little while ago. By a Nova is meant a star which suddenly appears in a spot where no star was previously known to exist.[1] In recent years a number of such new stars have been discovered, especially by photography, and in every case they have exhibited quite similar phenomena. The brightness increases enormously in a very short period of time; maximum brightness lasts for a few days or hours only and is followed by a more or less gradual decline which often proceeds to the point of absolute invisibility; and the various stages of its light curve are synchronal with well defined changes in the spectrum. Various explanations of these phenomena have been offered. Certainly a Nova is the result of a celestial catastrophe of some kind, but no completely satisfactory explanation of the nature of the catastrophe has so far been found. The most plausible theory (tho one not entirely free from objections) is that the outer strata of a dark or nearly dark star rushing thru a region of space filled with more or less dense nebulosity are heated to incandescence, the depth of the incandescent strata and the intensity of the consequent luminosity depending upon the degree of resistance encountered by the star. In at least one instance, *Nova Persei* of 1901, we know that the new star was attended by nebulosity which, in appearance, was expanding in all directions from the star. Now this nebulosity was not known before the star's outburst. Possibly it was entirely dark, like the nebula south of *Zeta Orionis*, but not dense enough to manifest itself by contrast, as the latter does; possibly it was feebly luminous and might have been detected had the region been photographed with a suitable telescope and a sufficiently long exposure. But tho unknown we

[1] In a few instances a very faint star has been identified with a Nova appearing later.

are reasonably certain that it existed independently of the star and was not a product of the latter's outburst, for the observed angular velocity, when converted into miles per second on the basis of the minimum possible distance separating us from the star, was so enormous that we cannot believe we were witnessing the actual translation of material particles. Far more reasonable is the hypothesis, first suggested by Kapteyn, that the apparent motion was due to the great wave of light sent out from the star. As this wave reached successive portions of the nebula these became visible to us, shining by reflected starlight as the Moon shines by reflected sunlight. After the wave passed, each part in succession again became invisible and the effect was that of nebular material moving radially from the star with the velocity of light. *Nova Persei* increased in light fully 60,000 fold (12 magnitudes) in less than five days, and quite rapidly lost a large portion of its light after reaching its maximum, and calculation has shown that when it was at maximum brightness its light was intense enough to affect our photographic plates if reflected from nebulous matter at the distances where this was actually observed. Slipher's recent work, to which I have already referred, affords strong collateral evidence in support of this theory, inasmuch as it gives us instances of other nebulae which are quite probably shining in whole or in part by light reflected from the stars with which they are associated.

The Novae are exceedingly interesting objects and might well be made the subject of an independent lecture. Here I can only take time to tell you one or two of the latest news items we have regarding them. Up to July, 1917, 32 Novae had become known, the majority of them in comparatively recent years and largely thru the comparison of photographic plates. With but three exceptions all of these new stars were situated in the Milky Way; of the exceptional cases one was not a typical Nova and the other two appeared in spiral nebulae. Since July eight additional Novae have been announced, *every one of them in spiral nebulae.*[1]

Now this distribution is a very remarkable one, especially when we recall the fact that several different lines of investigation are leading astronomers to regard with increasing favor the theory that the spirals are not members of our own stellar system but are independent systems, "island universes." That the new stars are

[1] This statement was correct at the date of delivery of the lecture. Since then another new star (*Nova Monocerotis*) has been discovered in the Milky Way. A note relating to it will be found upon another page of the present number of these *Publications*.

actually in the spirals and not between us and the nebulae is beyond question. A single Nova might perhaps appear projected upon a nebula to which it did not belong; that eight should appear in the line of sight toward some spiral nebula is, as Curtis has remarked "manifestly beyond the bounds of probability."

These recent discoveries are one result of the intensive study of the spirals which has been in progress at several different observatories in the last few years. It was Ritchey, at the Solar Observatory who found the first one. A photograph of the spiral known as N. G. C. 6946,[1] which he secured on July 19, 1917, with the 60-inch reflector, showed a star of 14.6 magnitude that did not exist on plates of the nebula taken in 1910, 1912, 1915 and 1916, some of which showed stars as faint as the 21st magnitude. By August 16 the star had lost more than half of its light and may now be once more too faint to be photographed.

Ritchey's discovery at once set astronomers at work comparing all available photographs of spirals. Curtis at the Lick Observatory promptly added three more Novae by his study of the Crossley reflector plates, and Ritchey, Pease and Shapley at the Solar Observatory increased the number to eight. The apparition period of a Nova may be limited to a few months or even to a few weeks and it is easy to see that many Novae may have appeared in spirals at times when no photographs were taken. Now that attention has been directed to their relatively frequent occurrence in these objects we may expect the number of such discoveries to increase more rapidly.

It is interesting to note that the new series of Novae are all very faint objects as seen from the Earth. On the average they have only reached the 14th magnitude at maximum brightness and at minimum light have certainly fallen below the 21st magnitude in nearly every instance. The Milky Way Novae discovered during the last 25 years have attained, at maximum, magnitudes ranging from about -0.5 to $+11$, the average being about $+6$, or eight magnitudes brighter than the average for the Novae in spirals.

Let us assume that, on the average, the new stars in the two sets attain the same absolute luminosity at maximum light; then it follows that, on the average, the Novae in spirals are at least 40 times as distant as those in our Milky Way. If we take 20,000 light years as the probable distance for the latter, the former are

[1] From its number in Dreyer's *New General Catalogue of Nebulae and Clusters of Stars.*

800,000 light years distant. It is obvious from such an argument that the discovery of Novae in spirals has a definite bearing upon the theory that the spirals are independent or "island universes."[1] The theory may not be correct, the argument may be fallacious; but it is just such hypotheses and deductions that the astronomer must make. For while it is his first duty, like that of the reporter for the daily press, to gather the facts and describe them accurately, his ultimate purpose, since he is a scientific investigator, is to correlate the newly observed facts with those already known and thus finally discover the natural laws of whose operation the phenomena are the manifestation. Even a false hypothesis may help him toward the truth provided he preserves an open mind and is willing to discard it or to modify it as additional facts may require.

It has been my endeavor in this hour's talk to bring before you a very few of the latest items of news from the stars and by means of them to illustrate the nature of the work upon which the astronomer is engaged. I have had another purpose also, and that is to take your thoughts away, for a short time, from the cares and anxieties of our every-day life. It is with deliberate purpose, too, that I have included in my items several which relate to the stars now visible in our early evening sky, for I hope that you may be led, from time to time, to look up thoughtfully at these stars. If you will do so, I think you will find that, as a recent English writer says, "the stars have a balm for us if we will but be silent," for the "huge and thoughtful night speaks a language simple, august, universal."

"It is one of the minor consolations of the war," continues this writer, who is personally doing his utmost to support his government in the prosecution of the war, "that it has given us in London a chance of hearing that language. The lamps of the street are blotted out, and the lamps above are visible—the great procession of the stars is the most astonishing spectacle offered to men. Emerson said that if we only saw it once in a hundred years we should spend years in preparing for the vision. It is hung out for us every night, and we barely give it a glance. And yet it is well worth glancing at. It is the best corrective for this agitated little mad-house in which we dwell and quarrel and fight and die. It gives us a new scale of measurement and a new order of ideas. Even the war seems only a local affair of some ill-governed asylum in the presence of this ordered march of illimitable worlds."

Lick Observatory,
January, 1918.

[1] See the notes by Curtis and bv Shapley in these *Publications*, Vol. XXIX, p. 180 and p. 213.